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# REPORT

ON THE

# GEOLOGICAL AGE OF THE MISSISSIPPI DELTA

BY

PROFESSOR E. W. HILGARD

TO

GENERAL A. A. HUMPHREYS.

WASHINGTON.
GOVERNMENT PRINTING OFFICE.
1870.

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# REPORT

OF

# PROFESSOR E. W. HILGARD.

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OCTOBER, 1870.

DEAR SIR: I have the honor to submit to you herewith a detailed report and discussion of my examination of specimens from the New Orleans artesian well of 1856, which you in 1866 referred to me for the purpose of determining the geological age of the deposits penetrated.

The occasion which gave rise to this investigation was, as you will remember, a suggestion to you on the part of Sir Charles Lyell that the statement made in your "Report on the Mississippi River," p. 99, viz: "that the river is flowing through it [the delta region] in a channel belonging to a geological epoch antecedent to the present," should be subjected to the test of a comparison, by some competent observer, of the shells collected in sinking the artesian well at New Orleans, with those of the cretaceous and tertiary on the one hand, and those now inhabiting the Gulf of Mexico on the other. Mr. Lyell was inclined to think that the strata pierced at New Orleans, and forming the bed of the river at Bonnet Carré, might themselves be interpreted as belonging to the delta formation, since, judging from the profile given by the committee of the New Orleans Academy of Sciences, marine and fresh water strata might seem to be alternating in such a manner as to admit of that interpretation.

You ascertained, however, upon inquiry, that unfortunately the suite of specimens collected by the academy committee had been much broken and dilapidated during the war, while the gentleman who had been chiefly active in the matter, Dr. N. B. Benedict, then secretary of the academy, had since died. Nevertheless, a suite as complete as possible was made up, at your request, partly from the specimens remaining at the academy, partly from another suite collected by Dr. J. L. Riddell, (deceased,) and sampled for the purpose by his son, Dr. S. S. Riddell. A suite of fifty-one specimens, thus made up, was placed by you in my hands, together with specimens of soundings, &c., collected by the delta survey, under your charge, which had been previously examined, for the greater part, by Mr. L. S. Pourtales. Of the interesting report made to you by the latter gentleman, of the results of his microscopic examination of these specimens, a copy was also furnished me.

The general result of the preliminary examination made by myself immediately upon receipt of the collection is already known to you, and is given in the first volume of Sir Charles Lyell's "Principles of Geology," 10th edition, p. 459. Since then, I have not only made a full examination of the entire suite, but, as my knowledge of the general geology of the Gulf coast progressed, I have reviewed and repeated my previous work in many respects. The investigation was beset with many difficulties, not apparent at first sight. Not the least among these was the condition of the specimens, many of which had doubtless been exposed to dust, insects, &c., for years. This greatly increased the difficulties of

the microscopic investigation, especially since, in specimens which are mostly pulverulent, it was not only the remains of marine or fluviatile faunas and floras, but also all the infinite variety of objects which may result from the visits of roaches, spiders, "candle bugs," ichneumon wasps, flies, and the vegetable hairs, pollen, spores, &c., which may blow in through open windows, that had to be distinguished and eliminated. I have, for this reason, confined the detailed microscopic examination chiefly to critical specimens, and such as, being in lumps, offered some security against accidental contamination of the kind alluded to.

Other cases of doubt have arisen from the presence of a few large shell fragments in specimens which, otherwise, showed no evidence of marine origin, making it probable that these fragments were accidentally introduced either in the collection room or, perhaps, in the bore itself, where the shells of higher strata may easily adhere to some pasty borings while being drawn up in the auger.

The latter cause may also in a slight degree vitiate the mollusk fauna of lower strata. But the cause of the trouble and uncertainty regarding the debris of animalculæ, above referred to, does not with any degree of probability apply to the mollusks, unless we imagine the specimens to have been accidentally or wilfully commingled, which, so far as I am aware, there is no reason to suppose.

I have, therefore, not usually pursued the microscopic examination into detail where strata were well characterized by shells visible to the naked eye. The latter, of course, were frequently the larger species, always represented by fragments only, and the proper reference of the latter was, in numerous cases, a matter of no slight difficulty, and sometimes dependent upon a happy inspiration, not always at command. I have, in most cases, when any doubt could remain as to the specific reference of a fragment, verified the result by a comparison of microscopic characteristics with those of living species in the conchological collection of the University of Mississippi, (the Budd cabinet of shells,) or specimens collected by myself on the Gulf coast.

Unfortunately the minute surface markings, which in such cases may serve to identify species, are most frequently obliterated in those strata in which shells are usually most abundant, viz., those of beach sand.

The species named in the following record, and on the subjoined general profile, are, of course, only those of which the identity could be established at least with a degree of probability amounting almost to a certainty. There are among the debris, not identified, probably from 20 to 25 species which, while not identical with any of those mentioned, are yet too imperfectly represented to be positively identified with others, or, perhaps, to be reconstructed from such slender premises save by the aid of some lucky accident or inspiration indicating the proper direction.

The most hopeful field for additional identification lies, perhaps, among the large number of young shells which occurs at some points. Our knowledge of the development of most of the mollusks of our southern coast is too imperfect to serve for the identification of the species in a very infantile condition—in fact, as Mr. Conrad has remarked in a letter to me on the subject, the mollusk fauna of the Gulf is as yet, in a great measure, a *terra incognita*, and when we find, in littoral strata of no very ancient date, fossil shells not as yet described, it cannot with any degree of certainty be said that they may not yet be living on the waters off the Louisiana coast. The shells of Florida and the Antilles are comparatively well known, because readily accessible. But the mud flats of the Louisiana coast, apart from being rather an unpleasant

trysting-ground, do not offer to the amateur collector those brilliant inducements which, while in the main conducive chiefly to parlor ornamentation, yet collaterally bring about very frequently the discovery of species heretofore overlooked by professional naturalists.

So far from considering the subject in hand exhausted, I intend to pursue it further to the utmost extent of my ability, aided, as I hope, by additional borings into the strata of which a minute speck only has furnished the material for the present investigation.

*Record of the examination of specimens of borings from the New Orleans artesian wells.*

[The numbers of the specimens here given are independent of those of the strata in the profile.]

No. 1.—2 to 17 feet.—Buff and mouse-colored clayey silt, coherent, containing half-decayed rootlets and fibers, and ferruginous spots. Under the microscope it exhibits chiefly grains of clear quartz, mostly rounded, small. A few black grains, some mica.

No. $1^1$.—17 feet.—Woody stems, somewhat softened, of a shrub, or hard herbaceous plant.

No. 2.—Bottom of stratum, 2 to 17 feet.—Same as No. 1, but with more ferruginous concretions, yellow, scaly, or concentric.

No. $2^2$.—17 to 20 feet 10 inches.—Dark-colored, stiff clay, with some sand, and decayed rootlets, bark, &c. Dark-colored, rounded, hard ferruginous concretions.

No. 3.—20 feet 10 inches to 31 feet.—Gray silt, somewhat coherent; shows glistening points; under microscope shows pellucid quartz grains, rounded and angular in about equal proportions; a few dark grains, and little mica; no organisms.

No. 4.—31 to 38 feet.—Gray sandy clay, coherent, with many irridescent surfaces, some evidently casts of shells, while others seem to have been formed on the sides of the vessels, it being stated to have been of the consistency of porridge when extracted; contains some plates of mica and large rounded grains of white quartz; effervescent; no definite forms under microscope.

No. 5.—38 to 41 feet.—Gray sandy clay, as above; contains abundant spiculæ of sponges, acicular, ends bifurcate; arcuato-acicular and oblong stellate. With it two fragments of *Venus mercenaria*, perhaps accidental.

No. 6.—41 feet to 41 feet eight inches.—Chiefly coarse siliceous sand, part sharp, part rounded, mixed with a few fragments of shells, and grains of a black mineral, apparently tourmaline. Upon washing it yielded turbid water, which, under the microscope, showed fine sand and numerous small bodies of yellowish tint and pointed egg-shape, sometimes agglomerated into groups, not soluble in hydrochloric acid. *Cocconeis?*

No. 7.—41 (42?) feet.—Coarse rounded sand, with numerous shells, mostly broken, quite hard *Mactra lateralis, M. Sayi; Arca transversa, Cardium magnum, Tellina flexuosa, T. tenta, Lucina costata, Venus cribraria, Astarte lunulata, Pandora trilineata, Oliva literata, Natica pusilla, N. campeachensis, Acus dislocatum, Marginella limatula, Bullina cassalicubata.*

No. 8.—43 to 56 feet.—Quartzose sand, finer than No. 6, with more numerous black (sometimes triangularly prismatic) grains (tourmaline?) and debris of small shells, *Arca transversa, Tellina flexuosa, Mactra lateralis, Cardium* ——— *sp.*, (235 feet,) *Balanus*, fragments of *Echinoids*, and crabs. No very definite *Foraminifera* in the washings, (a *Coscinodiscus?*) and spicules. Sand grains, part sharp, part rounded.

No. 9.—56 to 66 feet.—Bluish-gray, fine marly sand; microscope shows many fragments of minute organisms; *Navicula*, *Actinoptychus*, and others. Many irridescent casts; great abundance of *Mactra lateralis*; *Cardium magnum*, *Tellina flexuosa*, *Natica campeachensis*. Sand grains part sharp, part rounded, with grains of green mineral, and some spicules.

No. 10.—66 to 69 feet.—Gray sand, pretty coarse, sharp, somewhat coherent, with *Mactra lateralis*, *Arca transversa*, *A. pexata*, *A. americana*, *Tellina flexuosa*, *T. alternata*, *Pholas costata*.

No. 11.—70 feet.—Coarse white beach sand, grains rounded, with a few debris of shells.

No. 12.—75 feet.—Sand similar to preceding, a little finer, with *Arca transversa*, *A. pexata*, *Venus cancellata*, *Anomia ephippium*, *Donax variabilis*, *Oliva mutica*, *Buccinum acutum*, *Balanas*.

No. 13.—80 feet.—Quartz sand of greenish tint, with black grains intermixed, like No. 8, but coarser, and with numerous fragments of infant shells, *Pholas*, *Arca*, *Mactra*, *Cardium*.

No. 14.—82½ feet.—Tough, greenish-gray clay, cutting very smoothly, with but little sand; some fragments of shells, *Arca transversa*, *Venus*, *Balanus*.

No. 15.—85 feet.—Sand similar to No. 8, but more greenish, and fewer fragments of shells, and some mica. Grains mostly rounded. A few spicules.

No. 16.—88 feet.—A piece of semilignitized wood. Gray, sandy clay, with white concretions of carbonate of lime. Sharp sand, but no *Foraminifera*.

No. 17.—89 feet.—Sand similar to No. 15, but no fragments of shells, or definite animalcules.

No. 18.—90 feet.—Yellowish-white or gray fine calcareous silt, somewhat coherent, strongly effervescent. Contains about one-third by bulk of fine siliceous sand, some fine mica scales, no shells or animalcules.

No. 19.—91 feet.—Sand like No. 15, with one fragment of a shell, (accidental?) No signs of animalcules. Quartz grains, mostly sharp, mixed with some yellow and black grains. Some scales of mica.

No. 20.—95 feet.—Fine gray sand or silt, slightly coherent and effervescent. Under microscope shows mostly sharp, transparent quartz grains mixed with yellow grains and green plates of mica, also transparent; a few black grains. A single straight spicule of doubtful character. Reëxamination, twice repeated, and with higher power, shows nothing more.

No. 21.—98 feet.—Greenish and yellow clay, slightly effervescent; contains some sand, no *Foraminifera*.

No. 22.—99 feet.—Fine greenish gray sand or silt, much like No. 20; effervescent. No animalculæ found. Washed to remove clay, leaves chiefly sharp quartzose sand with numerous mica scales; some black grains, mostly well rounded. One small quartz prism, and one of a green mineral, possibly a mica scale. No definite organisms.

No. 23.—104 feet.—Fine sandy mass, or silt, brownish-gray, like No. 18 in coherence and feel; more clayey than the preceding. Upon washing shows under microscope numerous scales of mica, also black and yellow grains, the former rounded, the quartz ores sharp.

No. 24.—109 feet.—Fine sand, greenish-drab, glistening with mica scales. Coarser than No. 22, which it otherwise resembles. Small fragments of shells, not recognizable; a striated piece of mother-of-pearl, hard. Decidedly of marine origin.

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(Here occurs the first serious gap; no specimen of the 34-foot clay stratum, No. 26 of profile in Humphreys' report.)

No. 25.—146 feet.—Sand, clay, and shells, *Arca transversa*, *Anomia ephippium*, *Pecten dendatus*, (Sow?) *Pecten sp. Gnathodon cuneatus.*

(No specimens of Nos. 28, 29, and 30, of Humphreys' report.)

No. 26.—153 feet.—Cypress bark.

No. 27.—170 to 175 feet.—Concretionary lumps of fine ferrugino-micaceous sand, cemented by lime, effervescent. No animalculæ found, under microscope, but microscopic rhombohedra of calcic carbonate.

No. 28.—195 feet.—Fine greenish-gray, clayey, micaceous sand, effervescent; grains mostly sharp.

(No specimen of clay, No. 42 of Humphreys' report.)

No. 29.—230 feet.—Sand like No. 28, with fragments of shells; *Arca transversa*, *Mactra lateralis.* No *Foraminifera* found.

No. 30.—235 feet.—Coarse sand with *Arca transversa*, *Mactra lateralis*, *Tellina flexuosa*, *T. tenera*, *Venus cribraria*, *Semele*, (*cancellato-lamellate*,) *n. sp.*, CON. *Cardium n. sp.*, CON., (allied to *C. graniferum*,) *Abra. n. sp.*, CON., (same as at 41 feet,) *Pecten dislocatum*, *Pecten sp.* (same as at 146 feet,) *Fasceolaria distans*, *Buccinum* (*Nassa*) *acutum*, *Acus dislocatum.*

No. 31.—241 feet.—Coarse quartzose sand with little mica and numerous black grains, which are fragments, part sharp, part rounded, of brown iron ore, or a conglomerate of sand grains and the ore. *Mactra lateralis*, *Arca transversa*, *Tellina*, bits of wood, sand grains, much rounded.

No. 32.—246 feet.—Quartzose sand, finer than the preceding, coherent, non-effervescent, micaceous, greenish-gray. No small fragments of shells; one large one of *Arca ponderosa*, perhaps accidental. No *foraminifera* or *diatoms.* (No specimens of the clay struck at 252 feet.)

No. 33.—293 feet.—Pretty fine, uniform greenish sand, somewhat coherent, not effervescent. Small fragments and iridescent impressions of shells.

No. 34.—302 feet (?)—Greenish clay, very meagre. Is marked as above, but probably corresponds to the clay at 322 feet.

No. 35.—340 feet.—Dark gray or mouse-colored, fine, sandy material, somewhat clayey, effervescent; under microscope, quartzose sand with a few dark grains, almost all sharp. With a 500-power nothing more is seen, save a few dark spherical bodies with indefinite light spots.

No. 36.—370 feet.—Loose, pure sand, chiefly clear quartz, some amethyst, rose, yellow, green, and opaque red quartz; a few black opaque grains. All very much rounded, evidently beach sand.

No. 37.—377 feet.—Same as above, but coarser, with shells and fragments much worn. *Astarte lunulata*, *Arca transversa*, (*A. ponderosa?*)

No. 38.—402 feet 3 inches.—Sand same as last, but less pure. *Mactra lateralis*, *Arca transversa*, *Venus sp.* Contains granules of sand cemented by a ferruginous cement.

No. 39.—413 feet.—Sand like No. 37, with *Tapes n. sp.*, CON, *Mactra lateralis.*

No. 40.—420 feet.—Same as last. *Acus dislocatum.*

No. 41.—430 feet.—Fine greenish sand, no shells, under microscope, grains much rounded, with lumps of ferrug. conglomerate. Some linear spicules; no other organic forms.

No. 42.—440 feet.—Greenish sand, somewhat coarser than the preceding, much rounded, no shells; some mica and black grains.

No. 43.—450 feet.—Same as the preceding.

No. 44.—463 feet.—Same as preceding, with small bits of wood, more probably recent than fossil.

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No. 45.—476 feet.—Same, with small fragments of shells. *Venus cancellata, Mactra lateralis, Tellina.*

No. 46.—475 feet.—A rounded, ferruginous, concretionary pebble, studded with *Turbinolia* and shell fragments.

No. 47.—480 feet.—Coarse rounded sand with shells. *Gnathodon cuneatus, Venus paphia, Arca transversa, A. ponderosa, Pecten dislocatum, Ostrea sp.* (resembling O. ———,) *Anomia ephippium.* (No specimen of the 63½-foot clay stratum.)

No. 48.—544 feet.—Fine dark greenish, clayey sand, coherent, not effervescent, with fragments and impressions of shells much decayed and mostly irrecognizable, (*Arca pexata?*) *Anomia ephippium, Lucina costata, Bullina canaliculata.*

No. 49.—Between 543½ and 546 feet.—Coarse white beach sand, with numerous shells. *Mactra lateralis, Arca transversa, A. ponderosa, Lucina costata, L. multilineata, Pholas costata, Artemis concentrica, Cardium n. sp.*, (same as at 43 to 56, and 235 feet.) *Bullina canaliculata, Oliva mutica, Pleurotoma cerinum, Buccinum acutum, Natica pusilla, Dentalium sp.*

No. 50.—570 feet.—Tough brown clay, inclosing fragments of shells. *Astarte lunulata, Arca transversa, Tapes n. sp.* CON.

No. 51.—630 feet.—Gray gritty clay, micaceous; no shells. *Foraminifera* rather abundant. (Pourtales.)

In order that the paleontological evidence furnished by the preceding record and profile may be more readily appreciated, I have tabulated the result, so as to show at a glance the fauna of each of the principal shell-bearing horizons, as well as the vertical range of each of the species determined. For comparison I have also placed alongside, columns showing the occurrence of these species in the waters of the Gulf of Mexico, and in the strata described as post-pleiocene and pleiocene by Tuomey and Holmes, which occur on the Carolina coast.

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*Table showing the distribution of species.*

| | NEW ORLEANS ARTESIAN WELL. | | | | | | | | Gulf of Mexico. | SOUTH CAROLINA. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 41 feet. | 66 feet. | 76 feet. | 146 feet. | 235 feet. | 480 feet. | 546 feet. | 570 feet. | | Post-pleiocene. | Pleiocene. |
| Pholas costata | F. | F. | ..... | ..... | F. | ..... | F. | ..... | F. | F. | F. |
| Mactra lateralis | F. | F. | ..... | ..... | F. | ..... | F. | ..... | F. | ..... | ..... |
| Mactra Sayi | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | ..... | ..... |
| Gnathodon cuneatus | ..... | ..... | ..... | F. | ..... | F. | ..... | ..... | F. | F. | F. |
| Abra, n. sp. Con | F. | ..... | ..... | ..... | F. | ..... | ..... | ..... | ..... | ..... | ..... |
| Tellina flexuosa | F. | F. | ..... | ..... | F. | ..... | ..... | ..... | F. | F. | F. |
| Tellina alternata | ..... | F. | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Tellina tenera | ..... | ..... | ..... | ..... | F. | ..... | ..... | F. | F. | ..... | ..... |
| Tellina tenta | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | ..... |
| Donax variabilis | F. | ..... | F. | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Pandora trilineata | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Venus cancellata | ..... | ..... | F. | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. |
| Venus paphia | ..... | ..... | ..... | ..... | ..... | F. | ..... | ..... | ..... | F. | F. |
| Venus cribraria | F. | ..... | ..... | ..... | F. | ..... | ..... | ..... | F. | F. | F. |
| Venus mercenaria | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Artemis concentrica | ..... | ..... | ..... | ..... | ..... | ..... | F. | ..... | F. | F. | F. |
| Tapes, n. sp. Con | ..... | ..... | ..... | ..... | ..... | 413 ft. | ..... | F. | ..... | ..... | ..... |
| Semele, n. sp. Con | ..... | ..... | ..... | ..... | F. | ..... | ..... | ..... | ..... | ..... | ..... |
| Cardium magnum | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Cardium, n. sp. Con | ..... | ..... | ..... | ..... | F. | ..... | F. | ..... | ..... | ..... | ..... |
| Astarte lunulata | F. | ..... | ..... | ..... | ..... | 377 ft. | ..... | F. | F. | F. | F. |
| Lucina costata | F. | ..... | ..... | ..... | ..... | ..... | F. | ..... | F. | F. | F. |
| Lucina multilineata | ..... | ..... | ..... | ..... | ..... | ..... | F. | ..... | F. | F. | F. |
| Arca transversa | F. | F. | F. | F. | F. | F. | F. | F. | F. | F. | F. |
| Arca pexata | ..... | F. | ..... | F. | ..... | ..... | F. | ..... | F. | F. | F. |
| Arca ponderosa | ..... | ..... | ..... | ..... | ..... | F. | F. | ..... | F. | F. | F. |
| Arca americana | ..... | F. | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Pecten dislocatum | ..... | ..... | ..... | ! | F. | F. | F. | ..... | F. | F. | ..... |
| Pecten dentatus (?) | ..... | ..... | ..... | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Anomia ephippium | ..... | ..... | ..... | F. | ..... | ..... | F. | F. | F. | F. | F. |
| Bullina canaliculata | F. | ..... | ..... | ..... | ..... | ..... | F. | ..... | F. | ..... | ..... |
| Natica pusilla | F. | ..... | ..... | ..... | ..... | ..... | F. | ..... | F. | F. | ..... |
| Natica campeachensis | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Marginella limatula | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. | F. |
| Oliva literata | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | F. |
| Oliva mutica | F. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. | ..... |
| Pleurotoma cerinum | ..... | ..... | ..... | ..... | ..... | ..... | F. | ..... | ..... | F. | ..... |
| Fasciolaria distans | ..... | ..... | ..... | ..... | F. | ..... | ..... | ..... | ..... | F. | F. |
| Buccinum acutum | ..... | ..... | F. | ..... | F. | ..... | F. | ..... | F. | F. | ..... |
| Acus dilectum | F. | ..... | ..... | ..... | F. | ..... | ..... | ..... | F. | F. | F. |
| Balanus sp | F. | ..... | F. | ..... | ..... | ..... | F. | ..... | ..... | ..... | ..... |

NOTE.—The letter F denotes that the species mentioned in the first column was found at the depth indicated in the headings above.

The first point requiring discussion, in view of the facts presented in this table, is whether there is any reason to assume that the marine strata penetrated do not all represent, substantially, the same geological age.

I do not think that either the paleontological or the lithological evidence justifies any such distinction. *Pholas costata*, *Mactra lateralis*, *Tellina flexuosa*, *Arca transversa*, *A. pexata*, *Astarte lunulata*, *Buccinum acutum*, form the prominent landmarks throughout. There are three horizons especially rich in species, viz: 41,235 and 546 feet, and their neighborhoods. These are so interconnected by community of species that a real difference in their facies cannot reasonably be claimed, especially when we take into account the fact that all the shells found at the lowest levels are also found either higher up, or living in the waters of the Gulf; that, therefore, their non-occurrence in the higher strata is merely a matter of local accident, and that we might thus with propriety register all the living species found at lower levels in the columns of the higher ones. When this is done, the identity of facies becomes almost absolute, except as regards the new species.

The latter, four in number, were submitted by me to the experienced

hands of Mr. Conrad, whose description of them and remarks I hope to include in this report. He observed, in letters on the subject, that two of them especially impressed him as being of miocene type, yet that, in view of our imperfect knowledge of the Gulf fauna, it could not be positively said that these small species were not living, and had escaped observation.

It happens that one of the shells in question, *Abra, n. sp.*, occurs at 41 feet, and that quite abundantly. It then recurs at 235 feet, together with two other *n. sp.*, a *Semele* and a *Cardium*, (of the type of *C.* ,) the latter occuring also both higher up (at 56–66 feet) and lower down, (at 546 feet.) The *n. sp.* of *Tapes*, in its turn, occurs above the latter point, (at 413 feet,) as well as below, (at 570 feet.)

It would thus seem probable that whatever significance may attach to the occurrence of these new species, must apply to the formation as a whole, since they overlap both above and below.

I confess that, with all due respect for the experienced eye of my honored friend, I cannot let the consideration of the somewhat foreign type of one or two of these shells outweigh the overwhelming evidence of the general similarity of facies and preponderance of species in favor of a much more modern age than the miocene. Apart from living species, the strata in question do not contain a single shell in common with the Virginia miocene. On the other hand, most of their fauna is represented in the deposits described as pleiocene by Tuomey and Holmes, occurring on the coast of South Carolina; and, as will be seen by reference to the table, there is a still greater coincidence with those described by the same authors as "post-pleiocene." Moreover, not only the leading shells of the New Orleans strata, but the entire list, excepting the new species, might be picked up in an hour's time on the beach of any of the islands of Mississippi Sound. Other, and especially larger shells, it is true, would also be found, but it would be difficult for the auger to bring up these in a recognizable condition unless the exterior markings should be as characteristic as in the case of *Cardium magnum*, *Artemis concentrica*, *Venus cribraria*, *Pholas costata*, &c. Fragments capable of being interpreted as belonging, e. g., to the large *fusideæ*, usually washed ashore, are not wanting. Yet the probability of striking single large shells is vastly less than that of finding the smaller species, whose individuals are usually much more numerous, though when scattered on the beach they do not attract attention nearly as much as the sparse individuals of larger species.

It may be well to divest the question of the now somewhat indefinite terms which, in systematic geology, have long and usefully served in the subdivision of the later geological periods. It would puzzle most geologists at the present day to define the exact limits between the tertiary and quaternary, because in all probability no such line of division exists in nature. And when it comes to discussing whether a certain isolated formation shall be called miocene, pleiocene, or pleistocene, upon the basis of paleontological data alone, the question assumes at times somewhat of the aspect of scholastic disquisitions of the olden time. And whether we hold the Darwinian view of the origin of species, or that of Owen, or even the old one of successive independent creations, it is not at all likely that in different localities there should have been simultaneously an equal or similar accretion or extinction of species, at a time when differences of climate were already as strongly defined as now, or even more so.

If it be deemed too improbable an assumption that the four new species might, in view of their minuteness, have remained unobserved,

though existing in the waters of the Louisiana coast, then the formation underlying New Orleans, from the depth of 31 feet down, must be accounted of pleiocene age at least, according to the usual definition; therefore anterior in point of time to the drift.

To the assumption, however, there are almost insuperable stratigraphical objections.

The various bodies of tertiary deposits, south of the Ohio River, conform sensibly to the general outline of the Gulf of Mexico, modified by the deep embayment which, in the earliest tertiary times, reached up into Southern Illinois. Each successive accumulation rendered this embayment less profound, until at the end of the latest unquestionably tertiary epoch, (that of the "Grand Gulf" rocks, when the Mexican Gulf was merely an inland sea of brackish water,) the shore line was almost exactly parallel to the present one, if we leave out of consideration the prominence of the delta. Now the Grand Gulf rocks are everywhere found overlaid by the deposits of the southern drift or Orange sand, which in their turn are covered, either by the Loess or Bluff formation, or, nearer the coast, both of Mississippi and Western Louisiana, by a series of deposits partly marine, partly of fresh water origin, and which, from their obvious connection with the well known Port Hudson strata, I have named the "Port Hudson group." These deposits were formed, of course, previous to the existence of the Mississippi of to-day; and it would be quite incomprehensible how they could be missing in the central, and therefore presumably deepest, part of the embayment, or be there replaced by a more ancient formation.

The strata overlying the drift have been found, in Calcasieu, of no less a thickness than 354 feet. As at New Orleans, they are here found to consist of alternating strata of sand, and dark-colored clays with vegetable remains, but only in their upper portion do marine fossils occur, and, further inland, fresh-water deposits alone exist.

On the Mississippi coast, the strata have not been penetrated to a greater depth than about 50 feet; here, too, marine and fresh-water deposits are not only superimposed, but in juxtaposition. Further inland, fresh-water strata only, with underlying drift, are found; and still higher up, the drift is found underlaid by the rocks of the Grand Gulf age.

There is no reason to suppose that midway between, in the axis of the Mississippi Valley, the condition of things should be otherwise. We should, however, expect that from the presumable greater depth of water in this axis, the formation would be thicker and more prevalently marine. If in Calcasieu, at a distance from any great channel, (unless the Sabine be accounted such,) the formation is found to be 350 feet thick, it need not surprise us that it should not have been passed through at 630, in the axis of the greatest channel in the world.

Much has been said of the possible effects of the earthquakes which so frequently startle, for a moment, the inhabitants of the Mississippi Valley; and it is more than likely that the record of such events as those of New Madrid and Reelfoot Lake will be found stamped upon many a dislocated stratum hereafter. But there is yet a wide difference between such effects and the legerdemain machinery of "local upheavals," which is so readily resorted to by amateurs for the explanation of any unusual phenomenon. The geology of the northern Gulf coast has been traced with no pointed graver, but has the rough, broad dashes of a charcoal sketch; and no mere presumptions based upon partial data can be allowed to upset the general order of things. The difficulty of explaining the presence of a truly "pleiocne stratum at New Orleans, consist-

ently with any probable geological hypothesis, is so great that I should rather take into consideration the possibility of extinct species being found in post-pleiocene deposits, if the new shells should not turn up living in the Gulf. Sir Charles Lyell still inclines, in a measure, to the opinion that the strata penetrated in the New Orleans well may be delta deposits. This supposition, however, appears to me to be incompatible not only with what we already know of the general geology and geological history of the lower Mississippi Valley, (as shown in former papers,) but with the character of the strata themselves. They are altogether too prevalently of a marine character, so far as examined.* Nothing that could properly be supposed to be river silt occurs below 108 feet, and that resembles rather the fresh-water lagoon deposits of *Petite Anse* and *Côte Blanche* than the true river silt, formed above 31 feet. The annual, or in some seasons rather mensual floods of the river ought to cause a much more frequent alternation and change in the character of the deposits than is actually found, especially in the lower portion of the profile. A river doubtless emptied into the great estuary during the Champlain period of slow depression, but it was not *the* Mississippi river of to-day, which excavated its bed partially into these very strata, and acquired its identity during the terrace epoch of elevation.

One capital objection to the delta-deposit character of these strata, is the absence, or extreme rarity, of the true river fossil, which is rarely absent even from the marine shell beaches of the present delta, viz., the driftwood, whose macerated debris, often not exceeding a few cells loosely coherent, meet the eye in every microscopic examination of the Mississippi delta deposits. This comminution and distribution is the inevitable result of the scouring, grinding, and bruising process, which every piece of driftwood undergoes during its voyage; and while, being readily moved along, these particles are not always abundant in the river silt proper, they rarely fail to show themselves in the delta formation. There is, of course, no lack of just such fossil wood in the upper portion of the formation, near what might, for a time, have been the mouth of a river, viz., at Port Hudson, and some distance below. But that river emptied, probably, into a maze of fresh or barely brackish lagoons, interspersed with cypress swamps; and as the depression progressed, the mouth of this continental outlet, receding gradually, must have been vaguely defined as the point where the waters that deposited the bluff formation ceased to have a sensible flow.

Trusting that this report, though long delayed, may be more satisfactory to you than it could have been at an earlier period, before more extended researches had rendered an intelligent discussion practicable,

I am, very respectfully, your obedient servant,

EUG. W. HILGARD,
*University of Mississippi.*

Brevet Major General A. A. HUMPHREYS,
*Chief of Engineers, Washington, D. C.*

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* I may add, also, without attaching undue importance to the circumstance, that I found the mollusk fauna thrown ashore on the mud lumps of the delta materially different from that usually cast upon the islands of Mississippi Sound, and but slightly represented among the fossils of the New Orleans well. *Arca transversa* and *Buccinum acutum* were the only representatives of that fauna, among about twenty species collected, almost all of which were univalves.

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*Profile of the artesian well at New Orleans.*

| No. | Nature of materials, as reported by the academy committee. | Thickness. | Nature of materials, from examination of specimens. | Depth. |
|---|---|---|---|---|
| | | *Feet.* | | *Feet.* |
| 1 | Surface soil | 2 | Surface soil | 2 |
| 2 | Clay, blue, tenacious, uniform | 15.0 | Clayey silt, buff and mouse colored, with half-decayed rootlets, fibers and stems, and ferruginous spots; at bottom of stratum ferruginous concretions, sandy, concentric structure | 17.0 |
| 3 | Clay, coal black, containing woody matter, rootlets, &c. | 3.8 | Clay, dark colored, stiff, with rootlets, &c., and hard, rounded, ferruginous concretions. | 20.8 |
| 4 | Sand and clay mixed; subtile, like annual deposits of the Mississippi River. | 10.2 | Silt, gray, coherent, with glistening points; under microscope pellucid quartz grains, both rounded and angular; few dark grains and mica scales | 31.0 |
| 5 | Clay, dark, semi-fluid, nearly destitute of grittiness. | 7.0 | Clay, slightly sandy, dark colored, with many iridescent surfaces, apparently casts of shells; effervescent with acids | 38.0 |
| 6 | Clay, same as preceding, but becoming sandier. | 3.0 | Clay, as above, more sandy; abundant sponge spicules; fragments of venus mercenaria | 41.0 |
| 7 | Sand, leaden blue, coarse; many small shells; water abundant. | 0.7 | Sand, coarse, rounded, with fragments of shells and cocconeis(?) | 41.7 |
| 8 | Shells exclusively, great variety, very compacted. | 1.3 | Mactra lateralis, M. sayi; arca transversa; donax variabilis; cardium magnum; tellina flexuosa, T. tenta; lucina costata; venus cribraria; astarte lunulata; abra sp. nov. Con.; pandora trilineata; oliva literata; marginella limatula; bullina canaliculata; natica pusilla; N. campeachensis; acus dislocatum; nassa acuta; coarse, rounded sand | 43.0 |
| 9 | Sand, like No. 7, with small shells | 13.0 | Quartzose sand, with little tourmaline, finer than No. 7; contains debris of small shells; arca transversa; tellina flexuosa; mactra lateralis; cardium sp. nov. Con.; balanus, echinoidea, crabs | 56.0 |
| 10 | Sand, clay, and shells mixed, olive colored, like mortar. | 10.0 | Sand, fine, bluish gray, marly, with fragments of shells and iridescent casts; mactra lateralis; tellina flexuosa; cardium magnum; natica campeachensis; navicula, actinoptychus, and other foraminifera; some spicules | 66.0 |
| 11 | Sand, coarse, dark brown; small cypress roots, pebbles. (?) | 4.0 | Sand, gray, coarse, coherent, sharp, with mactra lateralis, arca transversa, A. pexata, A. americana, tellina flexuosa, T. alternata, pholas costata | 69.0 |
| | | | Coarse white beach sand, with fragments of shells | 70.0 |
| 12 | Sand, coarse, light blue; no shells | 5.0 | No specimen | 75.0 |
| 13 | Sand, blue, with fragments of shells | 1.0 | Beach sand, with arca transversa, pexata, venus cancellata, anomia ephippium, donax variabilis, oliva mutica, bucinum acutum, balanus | 76.0 |
| 14 | Shells exclusively, compacted; pebbles in lowest part. | 6.5 | | 80.0 |
| | | | Quartzose sand, with numerous infant shells, pholas, arca, mactra, cardium | 82.5 |
| 15 | Clay, olive green, tenacious | 2.5 | Clay, tough, greenish; little sand, fragments of shells; arca transversa, venus, balanus, foraminifera | 85.0 |
| 16 | Impalpable sand | 3.0 | Sand, like 43 to 56 feet, more greenish; fewer shell fragments | 88.0 |
| 17 | Clay, like No. 15 | 1.0 | Clay, gray, sandy, with concretions of carb. lime, semi-lignitized wood. No animalculæ | 89.0 |

*Profile of the artesian well at New Orleans*—Continued.

| No. | Nature of materials, as reported by the academy committee. | Thickness. | Nature of materials, from examination of specimens. | Depth. |
|---|---|---|---|---|
| | | *Feet.* | | *Feet.* |
| 18 | Sand, gray or bluish | 1.0 | Sand, similar to preceding, but no shells or definite animalculæ | 90.0 |
| 19 | Clay, blue, with umber-colored concretions. | 1.0 | Silt, buff, calcareous, effervescent, coherent. No shells or animalculæ | 91.0 |
| 20 | Sand, blue, subtile, with some clay | 4.0 | Fine sand or silt, slightly effervescent and coherent; an indefinite spicule | 95.0 |
| 21 | Clay and sand, like No. 4 | 3.0 | Clay, greenish and yellow, slightly effervescent. No organisms | 98.0 |
| 22 | Clay, like No. 19 | 1.0 | Sand, or silt, fine greenish gray, much like that at 90 feet. No organisms | 99.0 |
| 23 | Sand, subtile, like German sand for fining glass. | 9.0 | | 104.0 |
| | | | Fine brownish gray silt, like that at 90 feet in coherence, more clayey than preceding. | 108.0 |
| 24 | Clay, dark, pure, tenacious | 1.0 | | 109.0 |
| 25 | Clay and sand, blue, soft; tools sink | 3.0 | Fine greenish drab sand, glistening with mica; small, irrecognizable fragments of shells | 112.0 |
| 26 | Clay, dark drab color, like tallow between teeth; effervesces with acids, leaving pores surrounded by a dark zone. | 34.0 | No specimen | 146.0 |
| 27 | Sand, clay, shells, and indurate clay | 3.0 | Sand, clay, and shells; area transversa, gnathodon cuneatus, anomia ephippium, pecten, 2 sp. | 149.0 |
| 28 | Clay, blue, tenacious | 0.2 | | 149.2 |
| 29 | Sand, &c., like No. 27 | 0.8 | | 150.0 |
| 30 | Clay, striated, changing into vegetable mold. | 3.0 | | 153.0 |
| 31 | Cypress log, sound, with striated plates of siliceous matter. | 0.5 | Cypress bark | 153.5 |
| 32 | Vegetable mold, changing into clay, with friable shells. | 1.0 | | 154.5 |
| 33 | Sand, greenish blue, with some clay | 2.0 | | 156.5 |
| 34 | Clay, pure, greenish blue | 9.5 | | 166.0 |
| 35 | Sand, very subtile, adhesive by little clay. | 4.0 | | 170.0 |
| 36 | Clay, drab, tenacious, with lumps like chocolate. | 5.0 | Concretionary lumps of ferruginous micaceous sand, effervescent; no fossils | 175.0 |
| 37 | Clay, dark umber color, tenacious | 1.0 | | 176.0 |
| 38 | Green sand, becoming clayey below | 4.0 | | 180.0 |
| 39 | Green clay, somewhat sandy | 2.0 | | 182.0 |
| 40 | Sand, like No. 38 | 1.0 | | 183.0 |
| 41 | Sand, coarse, whitish green | 13.0 | Fine greenish gray, clayey, micaceous sand, effervescent | 196.0 |
| 42 | Clay, leaden blue, not gritty; effervescent with acids. | 32.5 | No specimen | 228.5 |
| 43 | Sand, leaden blue, coarse; comminuted shells, a little clay. | 21.5 | Sand, like No. 28, with fragments of shells; mactra lateralis, area transversa. No foraminifera | 230.0 |
| | | | | 238.0 |
| | | | Sand, coarse, with area transversa, mactra lateralis, tellina flexuosa, T. tenera, venus cribraria, cardium sp. nov. Con. semele, sp. nov. Con., abra sp. nov. Con., pecten dilocatum, pecten sp. 146 feet; fasciolaria distans, acus dislocatum, buccinum (nassa) acutum. | 241.0 |

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*Profile of the artesian well at New Orleans*—Continued.

| No. | Nature of materials, as reported by the academy committee. | Thickness. | Nature of materials, from examination of specimens. | Depth. |
|---|---|---|---|---|
| | | *Feet.* | | *Feet.* |
| | | | Sand, coarse, effervescent, with ferruginous grains and fragments of shells and wood; area transversa, mactra lateralis, tellina. No foraminifera | 246. 0 |
| | | | Sand, finer than preceding, non-effervescent. No shell debris; area ponderosa? | 250. 0 |
| 44 | Variegated clay and vegetable mold | 2. 0 | | 252. 0 |
| 45 | Clay, pale lead color, or dirty white, tenacious, unctuous, not gritty. | 39. 0 | No specimen | 291. 0 |
| 46 | Clay, sand and shells, soft mass | | Fine, uniform, greenish sand, not effervescent; fragments and iridescent casts of marine shells | 293. 0 |
| 47 | Sand, unmixed | 29. 0 | No specimen | 322. 0 |
| 48 | Clay, pale olive, very pure | 4. 0 | Greenish clay, very meager | 326. 0 |
| 49 | Sand, like No. 47 | 6. 0 | | 332. 0 |
| 50 | Clay, like No. 48 | 3. 0 | | 335. 0 |
| 51 | Sand, ash colored, coarse; artesian water. | 95. 0 | | 340. 0 |
| | | | Mouse colored, fine, sandy material, somewhat clayey; effervescent. No definite organisms | 370. 0 |
| | | | Sand, loose, pure, much rounded; beach sand | 377. 0 |
| | | | Sand, as above, with shells and fragments, much worn, grains coarser; astarte lunulata, area transversa, A. ponderosa? | 402. 3 |
| | | | Sand, as above, but less pure, some grains cemented by iron; mactra lateralis, area transversa, venus sp. | 413. 0 |
| | | | Sand, as at 377 feet; tapes n. sp. Con. Mactra lateralis | 420. 0 |
| | | | Sand, same as last; acus dislocatum | 430. 0 |
| 52 | Sand, nearly black, subtile; a little clay; 360 gallons water per hour. | 50. 0 | Sand, fine greenish, rounded, with conglomeratic ferruginous lumps; some linear spicules. No shells or foraminifera | 440. 0 |
| | | | Sand, same as preceding; coarser, much rounded. No shells | 450. 0 |
| | | | Sand, same as preceding | 463. 0 |
| | | | Sand, same as preceding, with small bits of wood. Accidental? | 476. 0 |
| | | | Sand, as above, with venus cancellata, mactra lateralis, tellina turbinella | |
| | | | Sand, coarse; ghathodon cuneatus, venus paphia, area transversa, A. ponderosa, pecten dislocatum, anomia ephippium | 480. 0 |
| 53 | Clay, blue, tenacious, firm; no water | 63. 5 | No specimen | 543. 5 |
| 55 | Sand, many minute shells and fragments | 2. 5 | Dark, greenish, clayey sand; area pexata, anomia ephippium, lucina costata, bullina canaliculata | 544. 0 |
| | | | Coarse white beach sand; mactra lateralis, lucina costata, area transversa, A. ponderosa, lucina multilineata, pholas costata, cardium n. sp. 235 feet; natica pusilla, nassa acuta, pleurotoma cerinum, bullina canaliculata, oliva mutica, dentalium, artemis concentrica | 546. 0 |
| 56 | Clay, blue, firm, tenacious | 20. 0 | No specimen | 566. 0 |

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*Profile of the artesian well at New Orleans*—Continued.

| No. | Nature of materials, as reported by the academy committee. | Thickness. | Nature of materials, from examination of specimens. | Depth. |
|---|---|---|---|---|
| | | *Feet.* | | *Feet.* |
| 57 | Sand | 2.5 | | 568.5 |
| 58 | Clay, as above | 16.0 | Tough, brown clay, astarte lunulata, area transversa, tapes n. sp. Con. 235 feet | 570.0 |
| | | | No specimen | 582.0 |
| 59 | Sand and little clay, of stony hardness | | | 584.0 |
| 60 | Gray clay | | Gray, gritty, micaceous clay. No shells. Many foraminifera. (Pourtales) | 630.0 |

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